Webdust

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SensIT PI Meeting

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http://www.cs.rutgers.edu/dataman/webdust

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Motivation

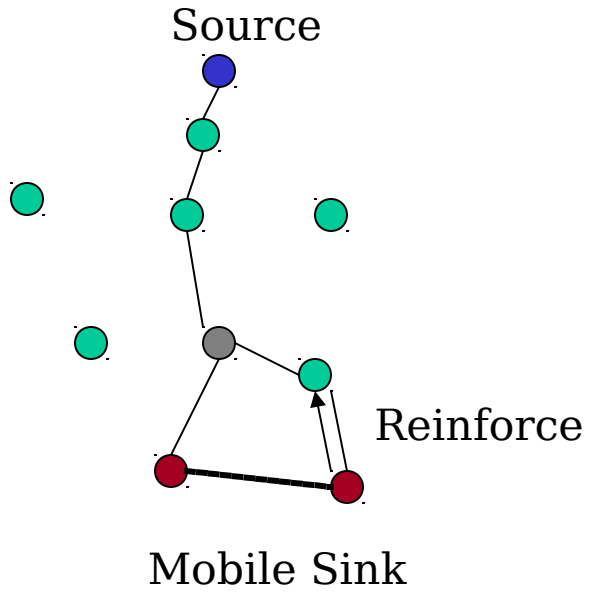
- **Problem of organizing, presenting, and managing rapidly changing information about physical space:**
  - Large scale micro-sensors networks
    - Billions of sensors (many of them mobile)
  - Fixed to mobile interaction
  - Ad-hoc positioning system
  - Predictive monitoring
  - Spatial Web
  - sensor Network Management Protocol (sNMP)
- **How to efficiently support gathering, collecting and delivering of information in sensor networks?**

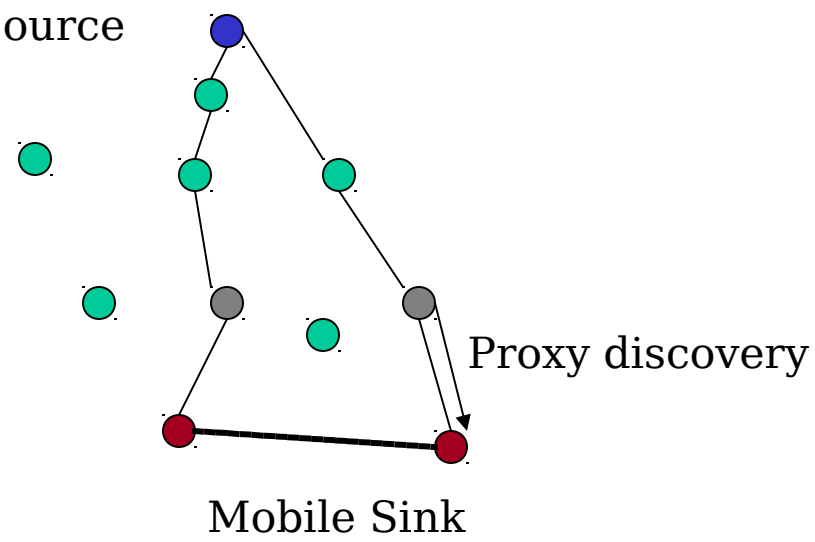
Approach

- **Build an infrastructure that will be able to provide an enhanced view of the surrounding physical space**
  - As users navigate physical space, they will be sprinkled with information (illuminated with information)
- **Idea: Closely tie location, communication (network), and information**
- **Main elements of webdust**
- **Mobility Support**
  - Allow querying from mobile objects in sensor fields
- **Ad-hoc Positioning System**
  - Derive values from other sensors; location orientation
- **Dataspaces/Premon**
  - Scalable query methods by using network primitives (broadcast, multicast, anycast, geocast, gathercast) and prediction techniques
- **Spatial web/sNMP**
  - Automatic indexing of spatial information
  - Crawl “physical space” to infer properties

Mobility support for diffusion

- **Add a special intermediary called the proxy**
- **Mobile sink sends proxy interest messages**
- **Only the new path between the proxy and sink reinforced**
- **Handoff scheme to allow two phase reinforcement**
- **Proxy discovery on big move (4 phase)**





Proxy

- **Special message type (proxy-interest)**
- **Proxy directly can reinforce to sink**
- **Tree not built all the way to the source**
- **Handoff mechanisms incorporated**
- **Make, make and break, break and make schemes**

Preliminary results

- **Mobility of 1-5m/sec**
- **Event deliver ratio (79-94% without proxy, 99% with proxy)**
- **Latency 40% improvement**
- **Energy – same**
- **Proxy-code to be made available**

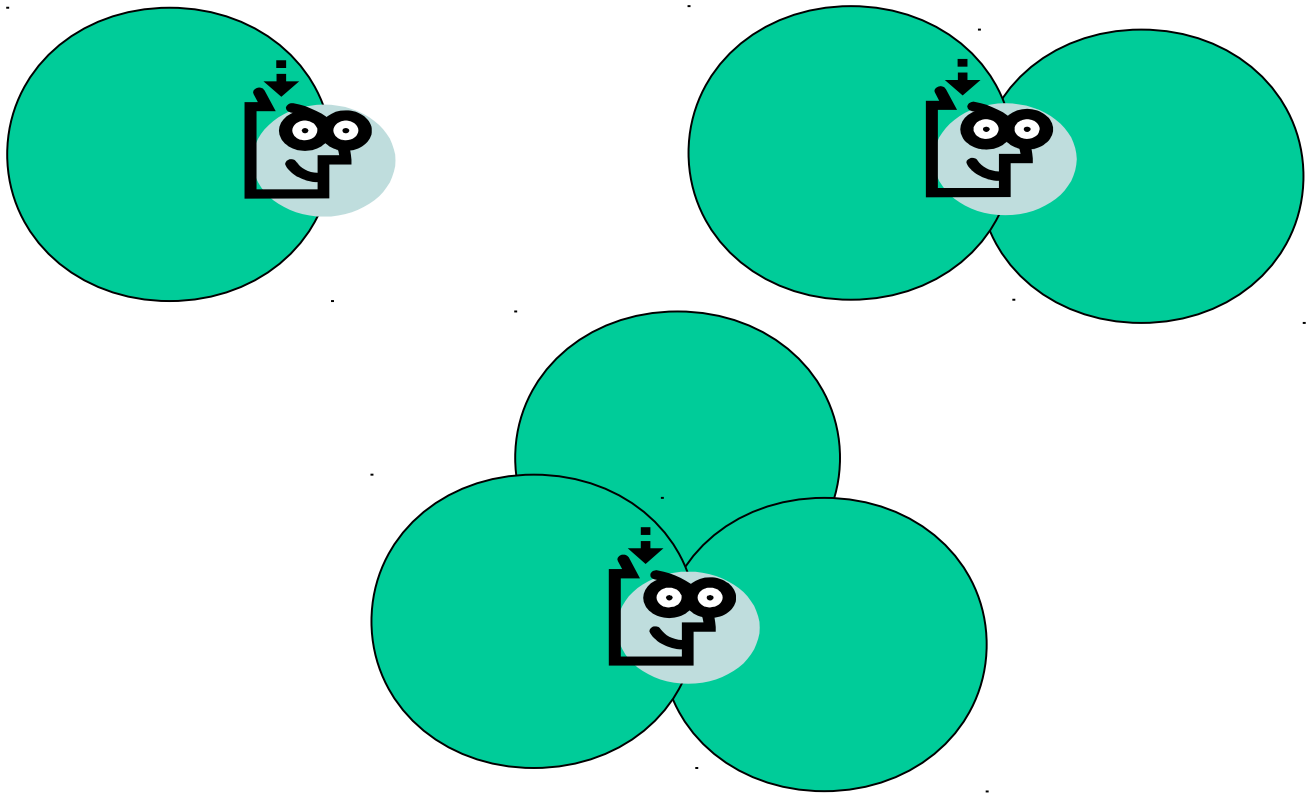
Deriving values in sensor networks

- **Deploy heterogeneous set of sensors**
- **Some able to sense a given attribute, some cannot**
- **Some able to sense with higher precision than others**
  - Due to Multimodality, proximity to action, expensive sensor etc
- **How can we add to information assurance**
- **One approach:**
- **If you don't know, ask!**
  - i.e., derive a value by using someone else's value
    - Location, range, orientation
  - Derive a value by knowing other attributes
    - Velocity, acceleration, time

APS: ad-hoc positioning system by Dragos Nicules and Badri Nath in Globecom 2001
AON: ad-hoc orientation system by Dragos Nicules and Badri Nath Rutgers Tech Rept.

APS (ad-hoc positioning system)

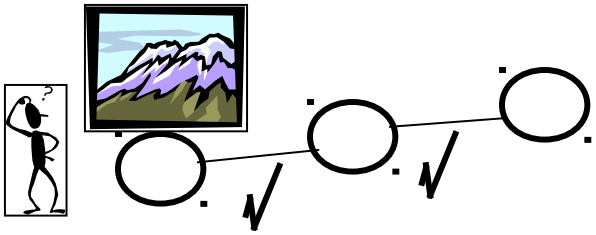
- **If you know ranges from landmarks, it is possible to derive your location (GPS)**



GPS accounts for error in measurements by making additional measurements

APS outline

- **Few nodes are authorities or landmarks**
- **Other nodes derive their locations by contacting these landmarks**
- **The contact need not be direct (like GPS)**
- **Nodes hidden by foliage, in caves!!**
- **To estimate distances to neighbors**
  - Use hop count, signal strength or euclidean distance
  - Use routing algorithm such as distance vector to get hop count, neighbor distances
- **Once distances to landmarks are known use triangulation to determine location**

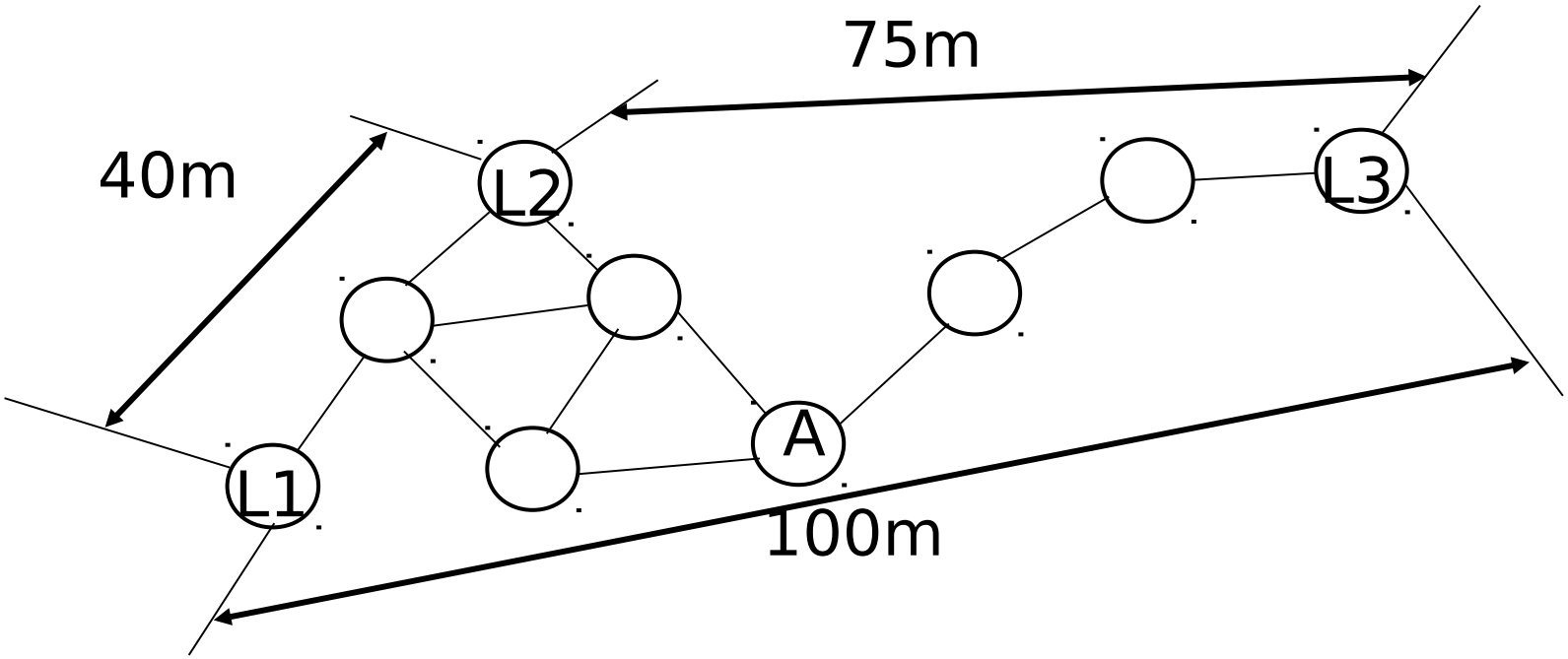


Know hops but do I know how far I am?

APS- distance propagation

- **Like in DV, neighbors exchange estimate distances to landmarks**
- **Propagation methods**
- **DV-hop- distance to landmark, in hops**
- **DV-distance – travel distance, say in meters (use Signal strength)**
- **DV-euclidean – euclidean distance to landmark**

DV-hop propagation example



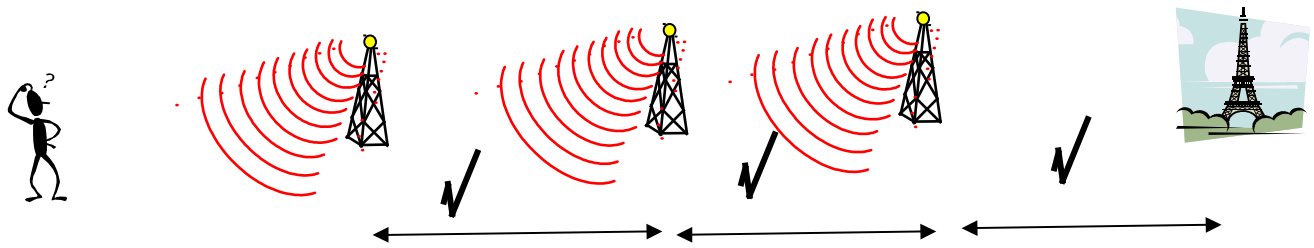
L1 → 100 + 40/(6+2) = 17.5
L2 → 40 + 75/(2+5) = 16.42
L3 → 75 + 100/(6+5) = 15.90

Dv-hop propagation

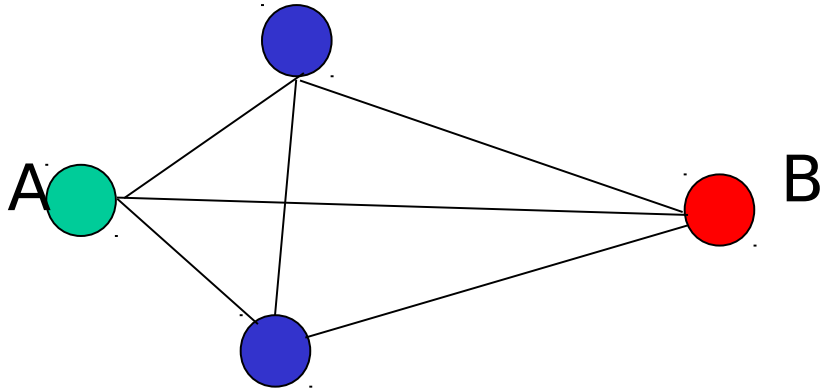
- **Landmarks compute average hop distance and propagate the correction**
- **Non-landmarks get the correction from a landmark and estimates its distances to other landmarks**
- **A gets a correction of 16.42 from L2**
- **It can estimate the distance to L1, L2, and L3 by multiplying this correction and the hop count**
- **A can then perform triangulation with the above ranges**

Dv-distance

- **Each node can propagate the distance to its neighbor to other nodes**
- **Distance to neighbor can be determined using signal strength**
- **Propagate distance, say in meters, instead of hops**
- **Apply the same algorithm as in DV-hop**

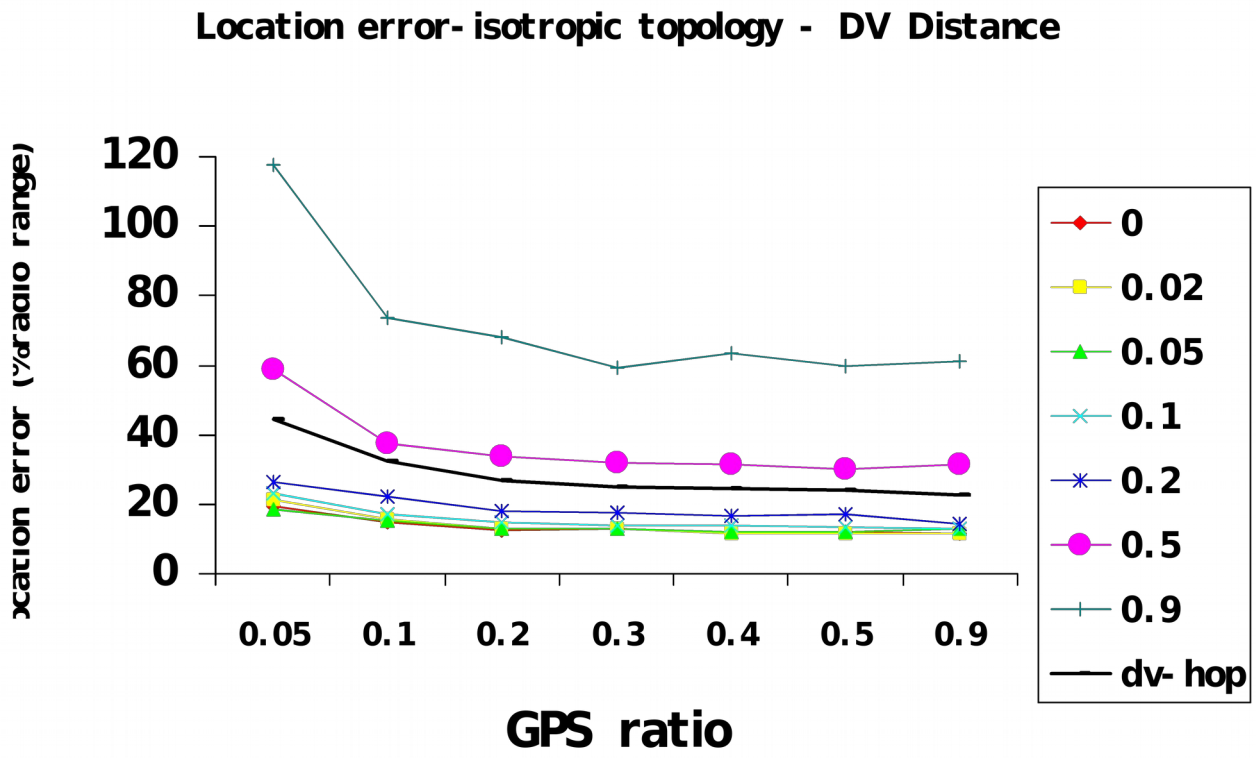


Euclidean distance

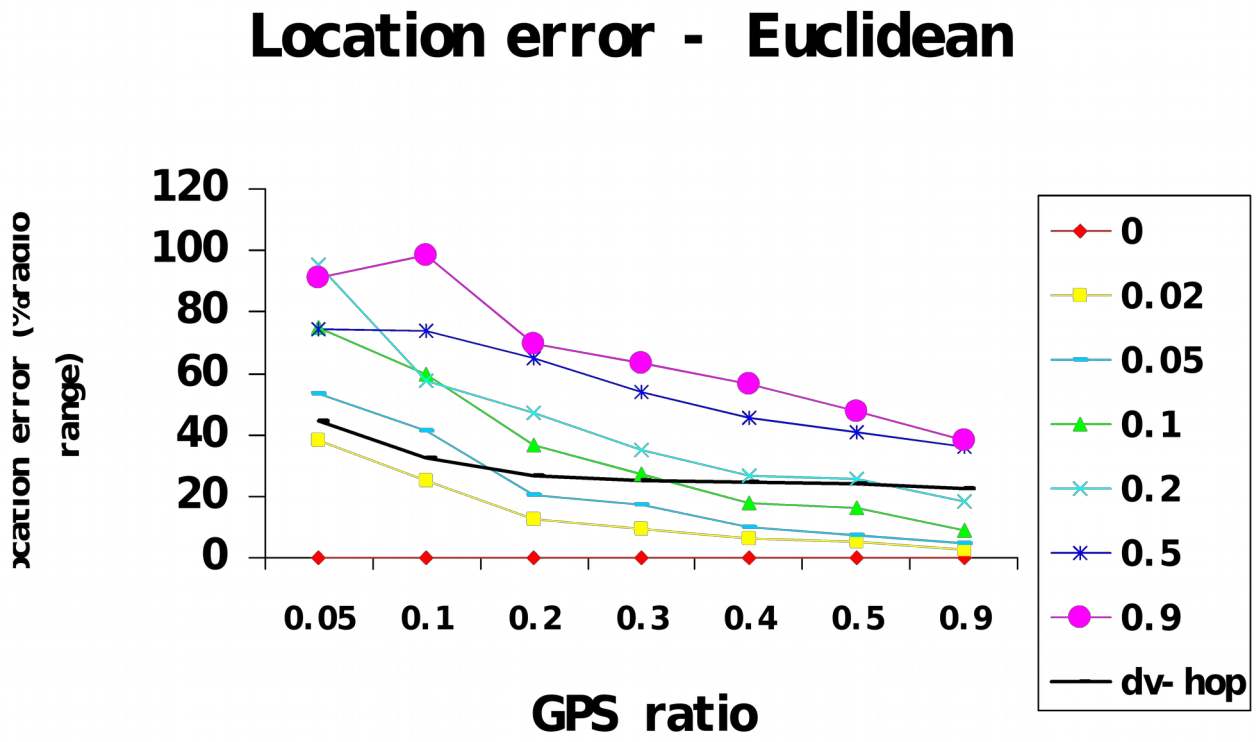


- **Contact two other neighbors who are neighbors of each other**
- **If they know their distance to a landmark**
- **One can determine the range to the landmark**
- **Three such ranges gives a localization**

Performance – location error

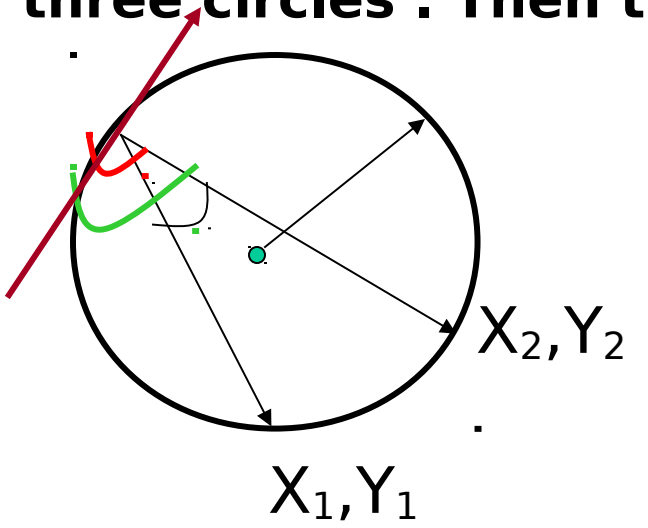


Performance – location error for euclidean



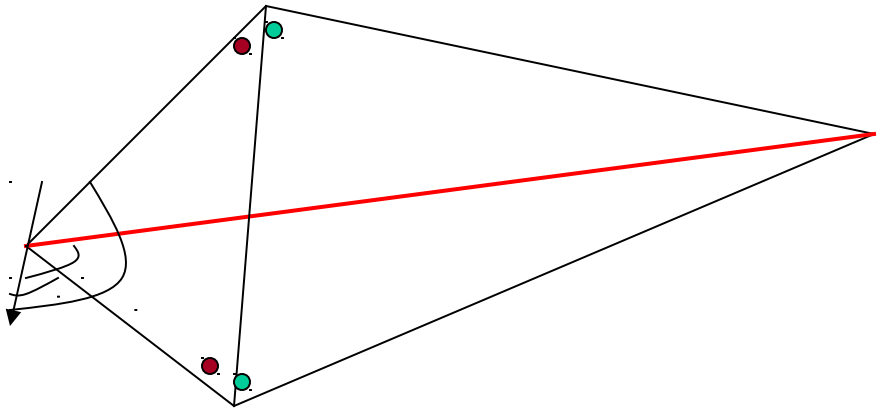
Angle of arrival

- **One can determine an orientation w.r.t a reference direction**
- **Angle of Arrival (AoA) from two different points (landmarks)**
- **Calculate radius and center of circle**
- **You can locate a point on a circle. Similar AoA from another point gives you three circles . Then triangulate to get a position**



Determining orientation in ad-hoc sensor network

- **Need to find two neighbors (B, C) and their AoA**
- **Determine AoA to the Landmark**
- **Once all angles are known, node A can determine orientation w.r.t a landmark. Repeat w.r.t two other landmarks, to determine position**



AoA capable nodes

- **Cricket Compass (MIT Mobicom 2000)**
  - Uses 5 ultra sound receivers
  - 0.8 cm each
  - A few centimeters across
  - Uses tdoa (time difference of arrival)
  - +/- 10% accuracy
- **Medusa sensor node (UCLA node)**
  - Mani Srivatsava et.al
- **Antenna Arrays**

Summary

- **All methods provide ways to enhance location determination**
- **Can provide location capability indoors**
- **Low landmarks ratio**
- **Suited well for isotropic networks**
- **General topologies**
- **Other attributes?**
- **Orientation, velocity, range, ….**

Related Work:

Positioning using a grid – UCLA

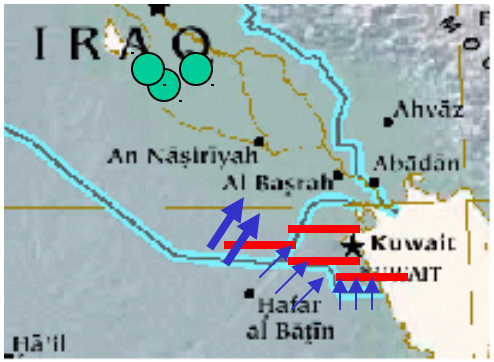
Using radio and ultrasound beacons – MIT cricket

Premapping radio propagation – Microsoft (RADAR)

Centralized solution -- Berkeley

WebDust Architecture

Landscape Database



SuperCluster

Spatial Web

Digital Sprinklers

Dataspaces (prediction-based)

Sensor Network

Conclusions

- **Mobility support for diffusion routing**
- **Handoff schemes**
- **APS system for orientation and position**
- **Spatial web**
- **Prediction based monitoring paradigm can significantly increase energy efficiency and reduce unnecessary communication**
- **Implemented this model on MOTEs**

Statement of Work

- **Task1: Proxy code available for Sensoria nodes**
- **Task2: APS implemented on sensoria nodes**
- **Task3: Spatial web**
- **Task4: Prototypes**

Information

- **http://www.cs.rutgers.edu/dataman**
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